THE INFLUENCE OF ATHLETIC TRAINING ON BLOOD-PRESSURE.

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The present study was undertaken with a view of determining the influence of a specified period of training on the blood-pressure. Because of the availability of material for study, football was taken as the type of athletic training for investigation. The men reporting for varsity and freshman teams are required to receive a permit to train from the medical adviser, and the present blood-pressure study represents merely an enlargement of this routine.

Blood-pressure readings were taken by the auscultatory method preceding and succeeding fifty stationary running steps before and after the football season, and then in May after a period of rest. Uniform hours were selected for all cases to eliminate possible error from diurnal variations. The fifty steps were controlled by commands as to height and rapidity, the steps being completed in twenty-five seconds (MacKenzie). The systolic and the diastolic readings were made with the patient in the sitting posture, with a Faught mercury manometer. The pulse rate was taken by an assistant. Then with the arm band still in place the fifty stationary steps were taken and second readings were made. The method is doubtless open to criticism, but, even though crude, the uniformity of results bespeaks its comparative accuracy.

The data are complete in the main for forty-five athletes completing the football season. The data of sixty-eight men who either failed to complete the season's training or to report at the end of the season are added to render the average of men entering training more general. In addition to the blood-pressure statistics, we will endeavor to show what percentage of athletes start the season with cardiac enlargement, and what proportion develop this condition during their period of training.

A comparison of the blood-pressure and pulse rate before training in both groups A and B shows a close coincidence in systolic, diastolic, and pulse-pressure, and in the pulse rate before and after the test exercise. We may therefore conclude that the complete group B is a fair average of men entering the sport.[1]

For their average age, twenty to twenty-one, the systolic pressure of 118 mm. Hg., and the diastolic pressure of 82 mm. are relatively high. Erlanger gives 100 to 110 mm. for the systolic and 60 to 70 mm. for the diastolic pressure at this age. A series of 20 non-athletic individuals in the University of Wisconsin[2] showed a systolic pressure of 111 mm. and a diastolic pressure of approximately 80 mm. The literature affords no normal reaction to test exercises.

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[1] More complete data will be found in tables in reprint of this article.

In our present study the presence of an increase in the reaction of cardiac activity attendant on slight exertion is noted among athletes out of training as compared with non-athletes. The non-athletes shows only a 32 per cent. increase in cardiac-rate on the exertion of fifty stationary steps,[3] whereas the average of the athletic groups is 45 and 44 per cent. It has been our observation that this condition pertains in a large proportion of athletes out of training. Pembrey and Todd[4] noted a similar reaction among men in training as compared with untrained, but offered no explanation.

From Group A the cases showing appreciable cardiac hypertrophy have been separated. Twenty-seven individuals (39 per cent. of the total) have this condition. The blood-pressure of these men coincides closely with the rest of the group.

The results of our observations on men completing their football training are compiled in Table I. For comparison the men are grouped according to increase, decrease, or stationary condition of blood-pressure; the number of individuals and percentages of the total these represent is stated along with change in millimeters of mercury. The pulse, systolic and diastolic phases of blood-pressure are grouped separately both before and after exercise, and in each of the periods, "after the season" is compared with "before season," "after a period of rest" is compared with "before" and "after season." These groups do not correspond to the large groups noted above. The total average increase or decrease for each phase of blood-pressure at each period is represented by the figures at the bottom of the table.

The total averages are probably better studied from the curves shown in Figs. 1 and 2. A normal curve is drawn for the blood-pressure before exercise, but as we have stated previously, no data are available for the normal reaction after exercise.

From Fig. 1 it will be noted that the systolic pressure of the athlete at rest before training averages 8 mm. of mercury higher than the resting non-athlete; the diastolic pressure is, however, 12 mm. higher in the average athlete. Therefore, the pulse-pressure in the resting athlete before the period of training averages 4 mm. less than the non-athlete. After the football training the following interesting condition pertains: The systolic pressure falls 6 mm., or to within 2 mm. of the normal, while the diastolic pressure fails to approach the normal line by 7 mm., not because there is not a fall relative to the systolic fall, but because of previous high diastolic

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[2] Shumacker and Middleton, Jour. Am. Med. Assn., 1914, lxii, 1136.

[3] Ibid.

[4] Jour. Phys., 1908, xxxvii, 66.

TABLE I.—COMPARISON OF BLOOD-PRESSURE IN FOOT-BALL MEN COMPLETING TRAINING SEASON.

		After season compared with before season.						After period of rest compared with:											
								Before season.						After season.					
		Before exercise.			After exercise.			Before exercise.			After exercise.			Before exercise.			After exercise.		
		Systolic.	Diastolic.	Pulse pressure.	Systolic.	Diastolic.	Pulse pressure.	Systolic.	Diastolic.	Pulse pressure.	Systolic.	Diastolic.	Pulse pressure.	Systolic.	Diastolic.	Pulse pressure.	Systolic.	Diastolic.	Pulse pressure.
Group A. Increased	Number of individuals.	11	11	21	14	16	19	28	26	22	22	18	19	35	30	20	24	24	21
	Percentage of total....	24.4	24.4	46.6	32.5	37.2	44.1	73.6	68.4	57.9	59.4	48.6	51.3	92.1	78.9	52.6	63.1	63.1	55.2
	Average in mm. of mercury..............	+5.0	+9.0	+6.0	+7.8	+5.7	+12.4	+9.8	+9.2	+7.8	+11.3	+7.5	+11.6	+12.5	+11.4	+7.7	+14.1	+8.5	+12.4
Group B. Decreased	Number of individuals.	30	28	21	25	22	21	8	8	13	12	14	12	2	3	12	5	7	13
	Percentage of total....	66.6	62.2	46.6	58.1	51.1	48.8	21.0	21.0	34.2	32.4	37.8	32.4	5.0	7.8	31.5	13.1	18.4	34.2
	Average in mm. of mercury..............	−10.0	−12	−7.3	−12.6	−13.9	−10.8	−5.5	−8.5	−8.6	−10.2	−11.0	−6.5	−13.0	−6.6	−6.2	−6.8	−4.8	−9.6
Group C. Unchanged	Number of individuals.	4	6	3	4	5	3	2	4	3	3	5	6	1	5	6	9	7	4
	Percentage of total....	8.8	13.3	6.6	9.3	11.6	6.9	5.0	10.5	7.8	8.1	13.5	16.2	2.6	13.1	15.7	23.6	18.4	10.5
Total Average	Increase (mm. of Hg.).	..	..	..	..	..	+1.0	+5.0	+4.0	+1.0	+4.0	+1.0	+3.0	+11.0	+9.0	+2.0	+8.0	+6.0	+2.0
	Decrease (mm. of Hg.).	−6.0	−5.0	−1.0	−4.0	−5.0													

pressure. With cessation of athletic training, both the systolic and diastolic pressures advance not only to, but beyond the anteseason records. This is a proportionate increase, and the pulse-pressure remains practically unaltered.

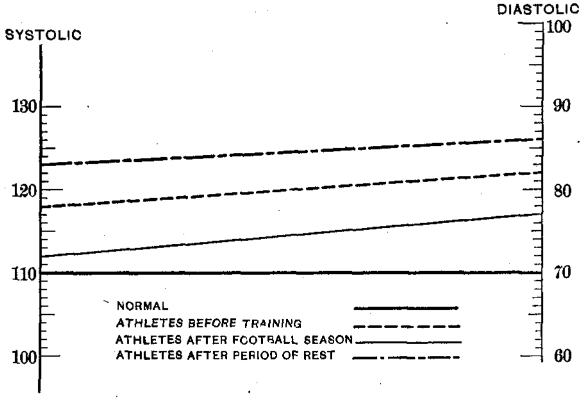

FIG. 1.—Total average blood-pressure in athlete before test exercise.

Fig. 2 indicates that the curves of blood-pressure after exercise follow the same general tendency of the systolic and the diastolic pressures of the resting readings at the corresponding periods. By this we mean that the "before training" curve occupies a position between the "after season" curve below and the "after period of rest" curve above, after exertion as well as in the resting state.

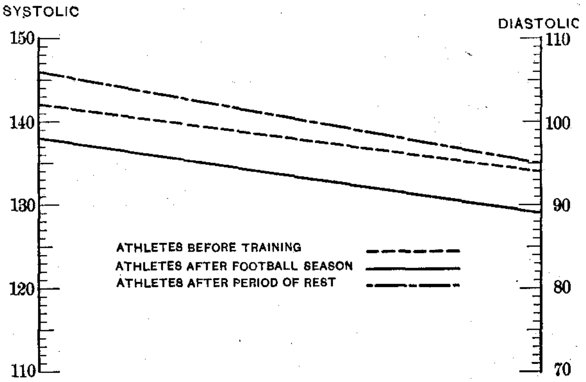

FIG. 2.—Total average blood-pressure in athlete after test exercise.

Of course, the diastolic pressure does not increase proportionately with the systolic pressure on sudden exertion.[5] This phenomenon leads to a marked increase in the pulse-pressure curves after exertion, which, with the increase in pulse rate, is interpreted by Lowsley to mean augmentation with acceleration of cardiac activity. Before training, on exertion, the average systolic pressure increase is 24 mm. Hg., while the average diastolic increase is 12 mm. After their football training the average systolic increase is 26 mm. and the average diastolic 12 mm. After a period of rest the systolic pressure reaction to fifty running steps is 23 mm., while the diastolic increase averages 9 mm.

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[5] Lowsley, Amer. Jour. Phys., 1911, xxvii, 446.

The possible relation between an increase in the skeletal musculature with a corresponding decrease in subcutaneous fat and these blood-pressure changes, *viz.*, the decrease of the systolic and diastolic readings with training, must be considered. Janeway[6] and Hensen[7] reported equal blood-pressure in arms of unequal size, and concluded that soft tissues played no important role in the blood-pressure readings. Von Recklinghausen's observations led him to the conclusion that with an arm band of 12 cm. or wider, soft tissues do not influence the blood-pressure readings. We followed the weight of twenty of the men through their training and found that no general rule could be applied; some men lost weight early in their training, but later regained the loss; some steadily lost while still others gained ground from the outset. There was no tendency on the part of those who lost weight to fall into a group of strikingly low pressure. On the other hand, gain in weight was no index for a rise in blood-pressure. As a matter of fact, while we assume that loss of weight being due to a combustion of subcutaneous and other stored fats to a large degree, and therefore assume that the removal of this tissue from the arms would lessen the resistance to compression, no confirmation could be found for such theory in even our most striking weight changes.[8]

CONCLUSIONS. The effects of a football training period on the blood-pressure are fairly constant, namely:

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[6] Arch. Int. Med., 1909, iii, 474.

[7] Deutsch. Arch. f. klin. Med., 1900, lxxii, 443.

[8] As to cardiac hypertrophy, in Group A, 27 individuals of a total of 68, or 39 per cent., had an enlarged area of cardiac dulness before the training period. In Group B, 28 men out of 45, 62 per cent., showed hypertrophy before training. The discrepancy here is explained by the fact that for the greater part Group A are freshmen, while the majority of Group B are varsity men. After the football season, of 45 men completing their training, 40 had cardiac hypertrophy. Of the 5 men completing the season without cardiac enlargement, our examination in May revealed the fact that 4 of these had developed an appreciable enlargement in the interval, and the fifth had in the meanwhile been forced to withdraw from the University on account of a questionable pulmonary lesion; 3 of the men had, however, engaged in some other sport, making the relation between their football training and cardiac condition questionable. These figures would seem to indicate rather conclusively that cardiac enlargement of a rather moderate degree is the natural consequence of the football training. In addition there is an apparent tendency for the enlargement to the right to disappear, and in certain cases, for the reduction of left-sided enlargement. There can be no question but that these cases represent hypertrophy with moderate dilatation. The failure of the cardiac enlargement to disappear in the five months intervening between the end of football season and our last examination in May seems to be fair proof of the permanency of this condition.

1. A proportionate decrease in both systolic and diastolic blood-pressure during the training period.
2. With a period of rest succeeding the training period, a rise of systolic and diastolic blood-pressure beyond the anteseason records.
3. The blood-pressure reaction to the given test of fifty stationary running steps is scarcely altered by a period of training.

As a basis for explanation for these phenomena several hypotheses may be stated:

(*a*) *Vascular Influence.* The decrease of blood-pressure during training may result from an enlargement of the vessels to the skeletal muscles with lessened peripheral resistance. Or this lessened peripheral resistance may result from a compensatory vasodilatation to accommodate for the increase in cardiac output and work from athletic training. From the vascular stand-point the secondary rise of blood-pressure after a period of rest would be explained by the logical assumption of a return of normal vasomotor tone, which in the presence of a hypertrophied myocardium, or increased cardiac power, would lead to increased blood-pressure from a relative increased peripheral resistance with an accompanying increase in systolic output. Moderate peripheral sclerosis from overstrain would likewise give increased resistance with a tendency to higher blood-pressure than normally existed in a given individual.

(*b*) *Cardiac Influence.* The primary decrease in blood-pressure after a period of training may be the result of a temporary moderate cardiac dilatation. By regaining normal myocardial tone with rest and the development of cardiac hypertrophy the increase of blood-pressure during this period may be explained.

Perhaps both of these factors are active in the production of the phenomena.

THE ADMINISTRATION OF GLUCOSE SOLUTIONS AS A PROPHYLACTIC AGAINST POST-OPERATIVE SHOCK.

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In a recent article[1] the writer has called attention to the present status of our knowledge of the various methods of parenteral nutrition. From the experimental data cited, it is apparent that, theoretically and practically, an animal may be kept for a considerable period in nitrogen equilibrium and at a constant weight by the intravenous injection of solutions containing amino-acids and glucose (Henrigues and Anderson). The subcutaneous administration of fats is possible, and they are apparently metabolized and supply a portion of caloric need of the organism.

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[1] Parenteral Nutrition and its Surgical Application, Med. Record, July 25, 1914.